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ECONOMY IN THE USE OF COMPRESSED AIR.

BY J. L. MITCHELL.

In considering the question of transmitting power to the machines used in mining, choice is limited to compressed air and electricity; the other means of steam and wire rope are inapplicable.

Steam is to a certain extent, out of place in a mine, although, under certain exceptional conditions, it is employed, and gives good results; but its use in confined spaces, where either coal cutting is in progress or rock drills are being worked, is quite out of the question.

Compressed air may be considered a perfect gas, and obeys the laws relating to such a body. That is to say, if the temperature be kept constant, the volume varies inversely as the pressure; if for example, the pressure is doubled, the volume will be reduced to one-half. If the volume be kept constant, the pressure varies directly as the temperature. Thus for every 5 deg. F increase in temperature, the volume is increased 1 per-cent. or for 100 deg. F, the volume is increased 20 per-cent.

If the above laws are clearly understood, it will be at once seen that great losses must occur in compressing air. When the volume in the cylinder is reduced by the piston, a considerable rise in temperature takes place, increasing the pressure one pound for each 5 deg. F, which at present is overcome by the expenditure of power, heat being simply work in another form. If the compressed air was used immediately at the point where it was generated, no loss would occur through heat. This however is never done; the heat produced by compression is lost in the transmission, and all the power which produced it, is lost also. The increase of temperature during compression expands the air in the cylinder and increases its pressure, so that the piston is met both by the natural resistance of the air to compression, and by the increased resistance due to expansion by heat. Another loss through this heating is that after the air leaves the cylinder and becomes cooled in the transmission pipes, the pressure falls with the temperature.

It has been noted in taking a card from the air compressor of to-day, that the air was compressed to four atmospheres after the piston had traveled 3–5 instead of 3–4 of the stroke, the compressed air occupying 2–5 instead of 1–4 of the space in the cylinder. Another loss is due to the fact that the sides of the cylinder become heated, and the air on entry is expanded, so that when the piston commences its stroke, the air contained in the cylinder is actually below atmospheric pressure. A small mass or weight of air is in the cylinder, but the increase of pressure due to the temperature makes the pressure normal. From these considerations it follows that, to secure good results, there should be first thorough cooling during compression, and second, the air on introduction, should have as low an initial temperature as possible. It is well worth the trouble for any parties who may be interested in an air plant for underground transmission, to locate with the view of keeping pipes and receiver as cool as possible. In any case it is well to observe the following rules:

First. — Cool the air and remove the dust before admitting it to compression. This prevents the air valves from cutting and gumming, also increases the life of the compressor as well as of the air motors.

Second. — If not convenient to place the receiver in a cool place, arrange a tank with sufficient size to submerge the receiver in order to keep a current of water passing around it.

Third. — Keep receiver as close to air motor as possible.

Fourth. — Always place a receiver between the air motor and long lines of pipe to catch the moisture.

Fifth. — It has been found that arranging an air way with sufficient area to prevent friction and long enough to cool and purify the air before reaching the air cylinder, has been very beneficial in the way of freeing the air from grit and dust, also reducing the temperature on entering the cylinder; the air-way being provided with a water jet spray at the egress and an air jet between the water jet and cylinder. The spray removes the dust, while the air jet being properly cooled before escaping, reduces the temperature sufficiently to deposit the moisture to a great extent, increasing the density of the air entering the cylinder. In freezing weather the water jet can be shut off.

To secure economy and good results, air should be compressed to 300 pounds to the square inch with large storage capacity placed as near the air motor as possible, and with an automatic pressure-regulating valve between receiver and motor, to reduce the pressure to what is required. If the air is cooled in stages, a high pressure can be produced with small loss through heat, reducing friction in pipes, giving time for proper cooling and for

depositing moisture. With the extra high pressure, the compressor has a chance to store up air at intervals while the motors are not running, thus keeping a large volume of air with a much smaller compressor.

THE CHAIR: Gentleman, the paper is open for discussion. If there is no discussion, there are a few matters that we had better attend to and I think we had better go into business session and attend to them. We have in the first place the reports of some committees. We have the election of members and the election of officers, which should be attended to at once. Before coming to this, however, I want to say one word in regard to the excursion to Congo. Arrangements have been made to take the members of the institute an their friends, so that you are all invited and are to invite your friends, members of the institute and their friends to go to Congo. The invitation is from H. D. Turney & Co. to take you down to the Congo mine, the newest and one of the most elaborately equipped mines in Perry County. The train will leave to-morrow at 7:45 and returning will arrive at Columbus at 5:50 I believe. By taking this train at 7:35 in the morning, you will have several hours at Congo and be back in Columbus by 6:00 o'clock to-morrow night, standard time. In regard to the entertainment at Congo, I will ask Mr. Ray to give us the arrangements.

MR. RAY: I will say the company will not give you a very elaborate meal, but a good clean meal with lots of sustaining qualities at the hotel. Arrangements have been made for 129. If more go, there will be plenty of crumbs for them.

SECRETARY HASELTINE: Every member of the institute is permitted to invite his friends.

One more thing that must not be overlooked. We invite the ladies on this trip and we hope as many members of the institute as can will bring their wives and sweethearts and sisters along on the trip. The ladies are always invited on every excursion that the institute makes. We have never had an excursion that we didn't take the ladies along.

THE CHAIR: Now, the next business before us, I think is the election of members. We have a number of applications for membership.

The Secretary read the names of the list of applications for membership.

W. J. E. Carr, Mechanical Engineer.....Leavenworth, Kan.
D. N. Osyor, Elec. Mining Engineer.....Columbus, O.
G. W. Greenwood, Mechanical Engineer.....Columbus, O.
Richard Prosser, Miner.....New Lisbon, O.
Henry Moss, Mine Supt.....Byesville, O.
George W. Davis, Mine Supt.....Wellston, O.
David M. Wise, C. & M. Eng.....Youngstown, O.
George Rowland, Mining Eng.....Jackson, O.
D. P. Lewis, Mining Eng.....Jackson, O.
David Ritchie, Mining Eng.....Wellston, O.
W. B. Montgomery, Mine Supt.....Wellston, O.
Thos. P. Corcoran, Book-keeper.....Corning, O.
J. S. Doe, Mnfg. Ming. Machines.....Columbus, O.
John Kane, Editor.....Columbus, O.

THE CHAIR: Gentlemen, what is your pleasure in regard to these applications.

MR. JENNINGS: I move the Secretary be instructed to cast the ballot of the association for the election of these members.

The motion being seconded, was carried.

THE CHAIR: Those gentlemen whose names have been read are elected members of the institute. We have three committees to report now. The first of these is the committee on consideration of the distribution of journals. Is that committee ready to report.

MR. EDWARD ORTON: The committee has tried to get together several times but have not gotten together yet and have no report to make. I think we can have something ready by the evening session.

THE CHAIR: With the consent of the members, this committee will be continued, to report at the close of this evening's session. The other committee to report is on the question of back dues. The chairman of that committee is not present and we will have to wait until the chairman is here.

I will ask Captain Morris if he is ready to report.

CAPTAIN MORRIS: Yes sir, I am ready. Mr. President and members of the institute: The committee appointed to nominate officers for the ensuing year has arrived at the following conclusions: For president, Edward Orton, Jr.; for vice-president, Dan. Harry; for secretary and treasurer, R. M. Haseltine; executive committee, the president of course is one of them, Edward Orton, R. M. Haseltine and N. W. Lord; signed by the committee.

SECRETARY HASELTINE: Mr. Chairman, we are in the habit of electing three members as an executive committee, exclusive of the president and secretary, who are considered members ex-officio. We have always had a committee of three executive members.

CAPTAIN MORRIS: If that is the case, I move that the president appoint the other two.

THE CHAIR: The president does not like to take that responsibility. If the committee will make the nominations I believe it will be better.

SECRETAKY HASELTINE: Mr. President, while you are considering that matter, I would like to say that Mr. Osyer has a collection of exhibits, relics, that he has gathered up in the Alaska country. We were very highly entertained last night by Mr. Lord's paper on the Alaska survey. Mr. Osyer has a choice collection which he would like the members to examine. It is in the next room.

Now Mr. Morrison was to have a paper on that coal tipple, and the tipple was shipped here by express, but Mr. Morrison writes me he thinks it will be impossible for him to get here, as

he has an important meeting with parties who announced their intention of calling on him to-day. He said it was barely possible he would get here this evening. He asked me to unpack the tipple and distribute the circulars to the members and have them examined. I am still in hopes he will come in time for the evening meeting and be able to read his paper and exhibit his tipple. But in the interval you are invited to examine it critically and help yourself to the circulars which he has sent accompanying it. The amended report of the committee to nominate officers then nominates for the executive committee, N. W. Lord, F. A. Ray and J. L. Morris.

A MEMBER: I move you that the recommendation of the committee be concurred in and that the gentlemen designated be declared the officers of this institute for the ensuing year. The motion being seconded was carried.

THE CHAIR: The collection of Mr. Osyer is in the next room and it will be worth your while to stop and look at it.

Miscellaneous business is now in order. Is there anything to be brought before the institute in the way of new business?

PROF. SPERR: After the reading of Mr. Orton's paper on the clays of Ohio, I was somewhat surprised at first that no discussion followed, and yet it occurred to me that very few were interested in the clay mining industry. It has been a matter of wonder to me for some time why the clay mining industry should not be interested in this institute and I looked for some discussion at first. There are some members I believe here who are interested in the clay industry. I do not just recollect who they are. But I think perhaps we might follow the practice of some of our foreign country societies and refer this matter to something in the nature of a commission, appoint a committee to take the matter under consideration. Therefore I move you that a committee consisting of Mr. W. H. Jennings, Mr. F. A. Ray and Mr. Allen Lovejoy be appointed to consider this subject and report to the institute at its summer meeting, when some action can be taken, if it is desired to do so.

MR. EDE: I rise to second that. I have, during the last twelve months, been over almost the whole field of Ohio and I am now in St. Louis to examine the clay business. It is really the business of a mining engineer. I wish to second the motion.

MR. JENNINGS: I would like to ask what Prof. Sperr expects that committee to do. What are they appointed for.

PROF. SPERR: My idea was to take under consideration the suggestions offered in Mr. Orton's paper and to get up an interest in betterment of the clay industry, the advancement of the clay interest in the state and incidentally to get the managers of the clay works interested in this institute and in their own self-advancement in the knowledge, if I may be permitted to say so, that it was suggested that they were very much in need of and very few of them possessed.

MR. ROY: It occurred to me too that it might be a good idea to follow up the course that was followed in the course of the department of the School of Mines, and to examine into the facts as to whether it would not be a good idea to see the Board of Trustees for the purpose of having added these studies that Mr. Orton spoke of in his paper in the mining engineer's course or some other associated course.

SECRETARY HASELTINE: I did not get the drift of this suggestion at first but now it strikes me that this is a splendid idea. I agree with my friend Roy on the advisability of broadening our School of Mines in that particular. Now if we are going to do something of that kind, let us do it like we did the School of Mines. We did not adjourn for a year, but we appointed a committee to get after the legislature or somebody, and we put the spur into them and we had the thing going inside of three months from the time the matter was brought up. Now if this is a good thing to do at all, it is a good thing to do quickly. Now I would like to ask Prof. Sperr to amend his motion and make this a committee to further this interest, if it is the desire of the Institute, and to broaden this course in the School of Mines and add to it in any way that is desired, to elicit the aid of the

clay manufacturers of the State of Ohio in coming into the society and helping to develop our clay industries. When I assumed the duties of Inspector of Mines, my recollection of it now is that the clay product of the State of Ohio was less than a half a million of tons. It increased a hundred thousand a year and then two hundred thousand in a year or two, and my recollection is that there were over two million tons of fire-clay manufactured during '92 and I don't know what it will be in '93. It has been increasing rapidly. We have realized that it is getting in advance of us and it will behoove us now to make a stir to keep pace with the enterprise. I offer this suggestion. I did not fully grasp the situation and may be I do not now, but, if it meets with Prof. Sperr's approval, I think we will encourage the clay manufacturers to come in and assist us and broaden our field of usefulness as well as that of the university.

PROF. SPERR: The reason that I did not put that in this form "To further the clay industries of Ohio," was simply from this fact, that our clay industries are so little represented in this Institute and for us who are interested almost altogether in coal mining to attempt to legislate for the clay industries without going about it very carefully and first consulting the clay industries and getting their views and perhaps getting a lively interest awakened in them in the matter and in the Institute appeared to me a question that was worth considering at least, and that it had perhaps better be left open and yet with that understanding of the matter, the sense in which it has been brought out, perhaps I would like to make the motion in that form, that a committee consisting of these gentlemen be appointed to ascertain what may be done to further the interests of the clay industries of the state and power to take such action as they may deem advisable in the mean time and to report at the next meeting of the Institute. If the second is willing, I will make it in that form.

MR. EDE: Yes, I will second the motion as amended in that form.

DR. ORTON: I was going to make a suggestion that if the summer meeting of the Institute should be held at one of these

clay working centers, an effort could then reasonably be made to interest the clay workers in the Institute. It will be necessary to get these people to recognize the value that the association will be to them. I did not see any fault with the original motion. It names a committee who may interest themselves in looking up the clay workers of the state.

SECRETARY HASELTINE: We hardly ever have the summer meeting where that would be feasible. We always have an excursion and just a kind of a junketing party without any official importance.

THE CHAIR: Gentlemen, it strikes me this is a little premature. Mr. Orton's paper was a very strong statement of the needs of an important industry in the state. That industry is represented in our membership. Now it strikes me the policy of this institute should be to get into it all this class of industries, and it strikes me this committee should be charged very largely with the power of drawing the clay working industries into the fold of the institute. I think the thing this committee should do would be to bring this matter before the clay industries and bring the clay industries into connection with us, also to explain to them that we are prepared to co-operate with them in the development of this line of work. Now it strikes me that it is proper to appoint a committee and give that committee pretty broad power, specifically charged in the direction of bringing about a closer connection between the clay workers and this institute and to bring before the clay industries and those interested in them the points that have been suggested; in other words, this committee can bring before those interested in the clay industries the idea that certain kinds of instructions, certain additions to the university would be greatly to their benefit and then co-operate with them and arouse the enthusiasm of the clay workers in this matter. Now, as I understand the resolution, it is this, a committee consisting of Mr. Jennings, Mr. Ray and Mr. Lovejoy be appointed to ascertain what can be done to further the interests of the clay industries of Ohio and bring the clay operators into closer relationship with the mining institute and to report at the next meeting of the institute.

MR. WILLARD: The clay workers of southern Ohio, and I guess of the whole State of Ohio, have a very perfect organization amongst themselves and have regular meetings, and if this committee would enter into communication with them they would perhaps get some information that would be valuable to them. I know they have regular meetings at Ironton and Portsmouth, and I think at Cincinnati too, and I think they have had a meeting further up the river. It is quite a large organization and a good deal of life in it. I have never attended any of their meetings, but it is a meeting of clay workers, brick makers and tile makers and such work as that. I am with a company that has paid a good deal of attention to fire-clay for the last 20 years. In fact we have supplied clay to the Cincinnati and Louisville potteries, etc., and through them I know they have an organization.

MR. EDWARD ORTON, JR.: I was asked something about what I said in my paper relative to the equipment of the university suitable for the education of clay workers. I did not intend to give the impression to the institute and I don't think my paper specified in any way that our equipment at the university was in any degree deficient or lacking in the kind of information the clay workers stand in need of. The question is right here, while all the branches that any clay worker needs to know about are all already in the university, they are not assembled in any one course so that a young man in coming there could not get the information he needs in any reasonable time. Now the other lines of study at the university, the electrical, engineering, mechanical, none of them come so close to the line of work the clay workers need as the mining engineers course. But I think it is almost impossible to affect any radical improvement or change in the clay working industries of the state by recommending to them the use of such facilities as we have. What they want is an especial bait thrown before them which shall indicate to them a training which is particularly for their benefit and designed to meet their immediate necessities. Now this is a great country, and Ohio is the greatest state in the Union in this line. Our clay working industries are constantly growing and are going soon to the point where they will over-

shadow the coal industries in this state. I presume dollar for dollar they are as important now as the coal and in a little while they are going to pass it. In all this broad country there is no technical school that I know of where any special inducement is made to these people or any course where clay workers can get what they want in any reasonable time. Now I think the time is ripe for Ohio to step in and establish such a school. We have a fine technical school at the State University and a course could be arranged there without making any radical additions or changes in the university force by which the clay workers could be accommodated, and after getting a short course there, perhaps a longer course could be afterwards added, which would rebound to the credit of the university and the state. Now the connection of the mining institute in all this matter is not as clear as I would like to have it. Our constitution is certainly broad enough. It certainly gives us scope enough, but so far, in the history of the institute, very little connection has been maintained with the clay working element. I think that is wrong. The clay working industries, as I said is a mineral industry, but not strictly a mining industry. This mining institute—its duties ought to be so widely construed that the advancement of all of the branches of the mineral industries should be included in it. This is my opinion. Not coal and coal mining alone, but we should make an effort to draw in all the forms of the mineral industry.

THE CHAIR: If there is no further discussion, I will put the question on the appointment of this committee.

The motion was unanimously carried.

On motion of Captain Morris, the institute took a recess until 7 o'clock P. M.

EVENING SESSION, 7 O'CLOCK P. M.

The institute was called to order by the chair, who introduced DR. ORTON to the institute, who spoke as follows:

Mr. President and Gentlemen of the Institute: I am glad of the opportunity to bring before the institute the recently published portion of the Geology of Ohio, Volume 7, the last publication which I expect to bring out pertaining to the Geological Survey of the State. I wish to call your attention at this time to certain uses to which the maps that accompany volume 7 can be turned. And in the first place I am very glad of the opportunity to make my acknowledgments to the members of the institute for the kindly services which I have received from them. It was through the efficient labors of Prof. Lord, our president, and Mr. Haseltine, our secretary, that the legislature was persuaded to make the appropriation by which I could finish work which I had in hand. It had long been an ambition of mine to have the coal seams of the state separately mapped. I think I can show you what service there is in that line of work as I proceed. There are two sections in the economic division of the state which constitutes part first of my new volume, my last volume, part first being already issued. There are two chapters in this, or sections, to which I can refer with great confidence as being valuable contributions to the service of the state in its economic interests, the chapter on clay manufactures and the maps, and I can deal in commendation of both without any breach of modesty, for they are not my own work. The chapter on clays is the work of my son, Edward Orton, Jr., and for the maps I am largely indebted to Prof. C. N. Brown, professor of Engineering in the University, who, at the time of my disablement, kindly took the field work off of my hands. The work was carried forward under his superintendence by a half dozen assistants, to whose fidelity I must ever bear witness. The point to which I specially invite your attention then is these maps of the coal seams of the state. They make an important advance in our knowledge. The area of the coal measures was long ago determined. From 1869 to 1873 the boundary of the coal measures

as indicated upon this map was determined by Dr. Newberry and his assistants, and this is the area that he assigns. That area will remain essentially unchanged as long as maps are made, except for minor points that may need correction; for it conforms to the great facts of nature. There are ten thousand or more square miles of eastern Ohio that are occupied by rocks of the carboniferous age, and they are represented by the dark coloring of the map. You may ask why that is not enough to determine the coal resources of the state. You say, "here we have the area. Now all we need is to determine the thickness of the sheet of coal that covers this area." But the coal measures comprise, among other things, a dozen or more coal seams, distributed through 2,500 or 3,000 feet of stratified rocks. There are a dozen or more seams that we are mining under present conditions. Seams must have a certain thickness to warrant their exploitation. We can count about 20 separate coal beds in our great field that have a name and place in the scale. Several of those that I have not counted among those that are mined at the present time, are mined in neighborhood banks on a small scale in different parts of the state. But there are 12 or 13 seams which are capable of supporting, under proper conditions, mines that can contribute in the large way to the public supply. Now bear in mind, please, that these dozen seams and others associated with them are not distributed at random through these 2,500 or 3,000 feet. They are gathered in certain series. I will not stop to extend that series further than to mention the divisions. We have first the Conglomerate Coal Measures, then the Lower Coal Measures in which our great deposits of coal are found. Next come the Barren Measures, lower and upper. The Upper Coal Measures comprise two seams that are mineable. We were speaking this afternoon of the series into which these seams fall or arrange themselves. That is theoretical to some extent. I should have been glad, if time had allowed, to dwell a little on that subject, since there is a fascinating theory in connection with it, but laying all theories aside we know that where the seams are best developed in the lower coal measures, we have, at certain regular intervals, seams of coal taking their places in

the scale. These seams all dip to the eastward and southward in this portion of the state, to the southward in the eastern, and in the eastern most counties there is possibly a little westerly dip. In the paper read this afternoon, there was a dip reported by one of your oldest members, Mr. Middleton, to the west of north. He finds a great coal swamp indicated here and at present the dip is towards the center of that swamp.

It is possible to trace these several seams. We can take any one of them and by patient labor and enough of it we can follow the seam through its outcrops on a county map, a map which has the name of every farm on it. By means of roads and farm lines and the government surveys by sections or otherwise, you can trace the outcropping of these seams. We come by and by upon areas that are cut off from the main stratum. Just as masses of the rocks themselves are cut off by erosion from the main stratum, so the coal seams are cut off, and tracts of a few hundred or a few thousand acres lie out of connection with the main sheet. The coal seams can also be followed until they descend below drainage. You can trace a seam as long as it is above drainage. You know the ear marks of a seam and how to keep upon its track. That is the kind of work that has been used in getting these boundaries. The maps to which I refer are put together here in the shape in which you see them. They are drawn on a scale of two miles to the inch. That is as large a scale as I could afford.

Now gentlemen, for this series of maps I have no apology to make. I used the appropriation that was made just as economically, just as carefully as it was possible to do, and got just as good work as it was possible to get. That I can say, and these outlines, if you will examine them carefully, I think you will see, could not have been made without a great deal of steady and continuous work. Many thousand miles of travel on foot around these borders are indicated by the boundaries that are delineated here. Many thousand miles of travel through sunshine and storm, through drought and through floods, have given us this great series of facts. These facts were not all gathered at the same time and I think you may say that the facts of Prof.

Brown's series are somewhat better than my own, those, viz: that were obtained a few years ago. In these I have not quite as much confidence. There is no material qualification to be made for them, but I can say that the boundaries of nature are a little better shown in these more recent boundaries than in some of the earlier. Still I am not here to apologize for the maps. While they stand ready to answer the purpose for which they were made, I will give one or two explanations in regard to them. It will be necessary, before I can make the story intelligible. The coal seams of Ohio that justify mining at any points in this state in a large way at the present time are named in their essential order as follows:

Sharon seam, Coal No. 1 (Newberry), Brier Hill, Massillon, Jackson shaft, etc.

Quakertown seam, Coal No. 2 (Newberry), Wellston, etc.

Lower Mercer seam, Coal No. 3 (Newberry).

Upper Mercer seam.

Brookville seam, Coal No. 4 (Newberry), Limestone Coal, Stark County.

Clarion seam, Coal No. 4 (Newberry), Limestone Coal, Vinton County.

Lower Kittanning seam, Coal No. 5 (Newberry), Mineral Point, etc.

Middle Kittanning seam, Coal No. 6 (Newberry), Nelsonville, Hocking Valley, etc.

Lower Freeport seam.

Upper Freeport seam, Coal No. 7 (Newberry), Cambridge, Salineville.

Mahoning seam, Groff-vein.

Pittsburgh seam, Coal No. 8 (Newberry), Pomeroy, etc.

Sewickley seam, Coal No. 9 (Newberry), Meigs Creek, etc.

We had a very interesting paper this afternoon on the limits of the Jackson County coal, the Wellston coal. There is a little of it shown in the Mahoning Valley here, but nothing but country banks.

Number 3 is the lower Mercer coal or the coal that underlies the blue lime-stone. The blue lime-stone sometimes disappears and only this element is left, as we were informed this afternoon, sometimes only one of the three elements, coal, lime and ore is left to mark the place. There are three or four things that be-

long to the family, but when you call at any particular place, the entire family is not always at home. You do not always find the coal and the lime-stone and the ore, but you will soon recognize whether you are at the place where they belong; but the lime-stone is wonderfully steady over large areas. It is what one of the geologists call the "blessed little lime-stone", because it turned up so regularly to show you where you were, geologically. This is the Lower Mercer coal. It is mined for railroad transportation in a single mine near Austintown. It is mined in Mahoning on a small scale and also in Hocking and Vinton counties. Then comes the Upper Mercer coal, which is 30 or 40 feet above it and which duplicates the history of this last named seam to a certain extent. The Bruce coal of Canfield belongs to the Upper Mercer horizon. Next above comes the Brookfield coal, of the Pennsylvania series. I do not know what number to apply to it here, as the numbers are confusing. We get along very well with one, two or three, but when we come to Upper Mercer coal, shall we call it 3 A or 4. 4 would be the regular order. Suppose we call it 4. Then we come to the Brookfield coal, which would be 5. But we have another 5 up above, so we have confusion at once. The Brookfield coal is the one that comes in under the Putnam Hill lime-stone. That is the ledge that makes so conspicuous a figure in Zanesville. It is shown in all the hills there. This Brookville coal develops a good deal of importance in Stark County, near Canton. It underlies a heavy ledge of lime-stone there. A number of banks have been worked along the Valley Railroad.

The next coal in order is one that many of you gentlemen know, those especially from southern Ohio, as the *Limestone coal.* This seam finds a small place in the Columbus market and competes on fairly successful terms with other coal. There is one mine that supplies coal from that seam that comes into market here. A considerable area of it is found in Vinton and Jackson counties. As we follow the gray lime-stone further to the southward, it loses its coal. Then we come to numbers 7 and 8, if we are counting in the true order, but 5 and 6 as they were counted in this portion of the state, or 3 and 4 as the numbers were fixed

upon them in eastern Ohio. It is that confusion of numbers that I have been so long protesting against and suggesting a remedy for by a better nomenclature.

These two companion seams can be traced all around the margin of the field even from Maryland, across Pennsylvania, all around Ohio and south 40 or 50 miles at least, into eastern Kentucky. These are the two Kittanning coals. Nos. 5 and 6 of our ordinary scale, 3 and 4 of Columbiana County. The lower or No. 5 is a seam of less steadiness than the one next to be named, but it has a wide distribution. The Middle Kittanning (I wish we could call it the upper Kittanning, but they have found a higher seam in Pennsylvania which they call by this name. It is the Pike Run coal of Tuscarawas County. It is the Coshocton coal, of Coshocton County. It is the upper Zanesville coal. It is the upper New Lexington coal. It is the Hocking Valley coal and the Sheridan coal of the Ohio river and the Ashland coal as you cross into Kentucky. This is one of the great seams of Ohio. It would be a great seam in any coal field.

This series is followed by another pair of seams that we call the Freeport coals, lower and upper. According to the old system of nomenclature, they were 5 and 6, in the eastern part of the state, they became 6 A and 7 further west and these perhaps are the numbers by which they are best known to-day. The lower Freeport is the Hatcher coal of southern Ohio and probably the Steubenville coal. The upper Freeport is the big vein of Salineville, the Cambridge and the Dell Roy coal, the Alexander coal near Zanesville, the Bayley's Run coal of Sunday Creek, and the Lucas coal of Jackson County. This is one of our most important seams. Just above it, 40 or 50 feet, lies a seam that is mined on Yellow Creek, the Mahoning or Brush Creek coal of Pennsylvania. It is commonly known as the Groff vein in eastern Ohio. Then above that at quite an interval and passing several small veins which are not important, comes the great Pittsburgh coal, probably the most valuable seam known in the world if we should rule out the anthracite seams. Outside of that it seems to me there is no seam in the world which has such extent and value. It has two principal areas. (Pointing to the

map.) This comes in on the hill-tops in Jefferson, in Harrison and Belmont, passes into Guernsey County, and is lost under cover in Monroe. But it is more clearly indicated in the smaller maps to which I will call your attention.

Above the Pittsburgh seam is the Sewickley or Meigs Creek coal, which is mined to quite an extent in Noble, Morgan and Muskingum counties. There is another field of the Pittsburgh coal, however that is developed in Meigs and Gallia with a few small outlines in Lawrence. These are the two divisions of the Pittsburgh, an eastern and a western. The Meigs Creek coal lies between them geographically. Now then, gentlemen, the first six of the seams that I named I have not undertaken to trace the outlines of these maps for reasons that I have already pointed out. They are not mined on a large scale. Their development is local. They have therefore been left out. I might apologize, if for anything, for having left out the famous coal of north-eastern Ohio, the Sharon seam, the Mahoning Valley coal, that perhaps has brought more money to its owners than any other equal coal area of the state. But that seam is mainly exhausted already. If I should put down the boundaries where the coal once was, the boundaries would be deceptive and the map misleading. But if I put down the boundaries of the small fragment that remains, the seam would appear insignificant.

The Jackson shaft coal I have not mentioned, the coal to which reference was made in Mr. Ede's paper this afternoon. It is indicated in a modest way with such extensions as we could find by the dotted line upon this map. I have not computed the areas of this seam.

There comes next the map of the two Kittanning coals. And now here is an explanation, not an apology. Poverty in doing the work for the state compelled us to put the two Kittanning coals together and the two Freeport coals together. The middle Kittanning coal which is the main seam, is the one whose margin is followed and the other coal is never more than fifty feet below and often not more than twenty feet and therefore a single boundary answers fairly well for both. The same thing is true in regard to the Freeport coals. The interval that separates

them is not more than fifty feet as a rule. My friend Mr. Haseltine had some very handsome maps constructed for the Exposition at Chicago and he separated all these seams. Each stands alone in its glory, making a very fine showing, but that result I was not able to reach. It was either what we did and in the way we did it or nothing at all. So we have represented by different symbols each seam. These two coal areas therefore stand for four seams of coal. But I think the mining engineer will find no trouble in taking this explanation and applying this to all these fields.

Again, when the Freeport coal is represented on the Kittanning area it goes without saying that the Kittanning coal lies underneath it. They cannot both be shown except by these boundaries, and therefore the areas of the Kittanning coal have to be connected underneath the Freeport coals.

The next seam to be mapped is of course the great Pittsburgh coal in its different areas. The next is the Meigs Creek or Sewickley. These are the seams that are represented on the maps. Four symbols have been used in setting forth upon the nine maps of the Survey the facts which I have now set before you. We have these four lines of boundary which gives us the ability to distinguish the areas of the two Kittanning seams, the Lower and Upper Freeport, the Meigs Creek and Pittsburgh coal —all the great seams except those I have already named in the introduction.

One thing more I would like to say in regard to these maps. Here for example you see an area in Jefferson County at this point. (Pointing to map.) That goes with full coloring at once to the boundary line and stops. That is not nature as you know. Nature does not pay attention to our superficial boundary lines. Why stop the representation of coal abruptly at this point? The answer is that we had some facts on one side of the line and had none on the other. The abrupt boundaries are in reality a pledge of coal beyond the lines that they cover. There are several coal fields which I have stopped with county boundaries, because I had data on one side and lacked them on the other.

I want to call your attention to one important point in this connection, and it is one in which I take great satisfaction. The *order of the coal seams* of the Ohio field is here finally demonstrated. These boundaries have been traced minutely and carefully from county to county, from township to township, and from farm to farm, and they demonstrate the persistency and continuity of the seams that are delineated. The old questions and controversies in regard to these seams can no longer be maintained. They are back numbers, past issues, they are out of date. We know where the Freeport coals come in and we know that they can be followed entirely through the coal field of Ohio. We know also that the Kittanning coals of Pennsylvania can be followed with perfect certainty across the state. We are just as certain of that as we are of the continuity of the Pittsburgh coal in Pennsylvania and Ohio and that has never been questioned. I take it this is a great advance for us. There are minor questions of identification such as came up this afternoon that are all full of interest and will be worked out by those who have access to the facts.

There is a coal in Stark County that is worked to some extent for local use that does not seem to match very well with any of the seams I have named. There are other cases of sporadic coals but I want to make a protest against the idea that a coal seam of three or four feet can come in at one place and never be heard of again. That is not the way of nature. If you stop to consider that a coal seam even of that thickness stands for a considerable period of time and certain climatic conditions, it will be seen to be highly improbable that any seam is limited to one little corner of the coal field. I am always on my guard against accepting these sporadic seams. It is a great deal more satisfactory when you find that though interrupted, they come in upon their true horizons.

I have, then, made the explanations necessary in regard to these maps. I come to the important use at which I have already hinted, the possibility of determining the coal resources of Ohio by means of them and I assert that now for the first time this possibility is within our reach. We know the outcrops. We

have traced them, we have followed them to the drainage level. The limit of drainage level is indicated in these maps, but the eastern boundary is not as carefully laid down as the outer boundary. It was not equally necessary to follow that minutely.

An important question arises however just at this point—an all-important question. How far below drainage shall we trace these seams? How far shall we consider them to extend below drainage? Now, I submit, that is a question of fact. Theory comes in to modify our views and we cannot get along without our theories, but at bottom it is a question of fact. Here again my friend Mr. Haseltine makes a very optimistic estimate. Every seam on his maps holds on to the Ohio river in almost unbroken line. He has given Ohio all the coal that it can possibly claim, to say the least. (Laughter and applause.) I hardly think however, that he would want to be held responsible for the presence of these seams through all these areas.

MR. HASELTINE: We were showing it to the world then.

DR. ORTON: I thought I understood the purpose. (Laughter.) There is always or at least generally some extension to the southward and eastward of these seams. I just called your attention to the fact that a coal seam does not come up to a county line and stop and if it is represented as stopping there, defective work is indicated or a lack of proper data. A coal seam does not come up to the point where it goes below drainage and stop abruptly. The present drainage is an accident of yesterday, as it is the erosion of recent times that has given us many of our valleys and drainage systems. The latter have nothing to do with the original location of these coal fields. These seams must go under cover. How far do they extend under cover? I say this is a question of fact and it is a question upon which every one of you that has any chance to make observations and to gather facts should consider himself bound to accumulate and use facts in the line of the public interest and service. The facts are derived from test borings, oil well records and the like.

Now I have comparatively few facts as to the extension of our seams under deep cover. I have gathered all I could. Many

of you have some that I have not. I have gathered them from all sources. Knowing that some extension of these seams must be provided for, I have assumed that we will give 20 or 25 miles in breadth to each coal swamp. I have measured a distance of 20 or 25 miles from the outcrop and indicate this boundary by a blue line (pointing to the map.) I would not be willing to stake my life on the presence of the seam beyond drainage. The boundary is not laid down at any particular point in the field with minuteness. It is merely an approximation and I am speaking of the possible use that these maps can be turned to. I want to assure you once again that I am not making any apology to-night for the maps. I am merely indicating the use to which they can be put. The work I have done here is hasty and crude. I was about entering on a laborious method of determining the areas in question, when my friend Prof. Brown interposed and offered to take this drudgery off my hands by the use of the planimeter. He has done this and has perhaps spent more time upon the substance of this paper than I have done, and has given me the data for the Kittanning seams (blue line) and the Freeport coals (red line). The maps will be in your own hands and each of you can make his own lowest or final boundaries. You have now the outer boundary and each will make his own inner boundary according to his theories or his facts.

In the case of the Pittsburgh coal I trace the areas that are above drainage in Belmont and Monroe counties, taking about half of Monroe—a little more than half, being guided in this by the recent drilling that has gone on there. The drillers declare they find a coal seam steady at a given depth, and this depth matches to the Pittsburgh horizon, and on their testimony I have indicated the coal many miles beyond where it has been definitely proved.

There is another point of vital importance in these measurements—you must have *area* not only but you must also have *thickness of the coal.* Now this thickness of the coal is a question of fact, but the *average* thickness is a question of judgment. That is for you to settle for yourselves from the several fields

with which you are familiar. Knowledge enough is all we want now, and this knowledge that remains to be gathered is a little easier to be gathered than the first perhaps. We can determine the average thickness from the published data of the mine inspectors report, but we could not get these boundaries without some general connected work, carried on throughout the state, and at the public expense. I will give an estimate of the thickness of the coal seams, but I do not ask any of you to accept it. I shall be glad of criticism and I shall not be at all disturbed if my estimates do not carry conviction with them. I have brought before you then the area of the coal fields, determined as I have indicated to you. Prof. Brown has given me the results of measurement in square miles for the several seams, or for the four I have named and for each county. Now, knowing the square miles of coal and the thickness of it, it is easy to make out a computation of total amount. The specific gravity of coal ranges from 1,24 to 1,34—somewhere about 1,28 or 1,29 is probably the average specific gravity of our Ohio coals. On that basis a cubic foot of coal, at 1,28 for example, weight 80 pounds and 25 cubic feet make a ton. You have a rule that 27 cubic feet make a ton I think.

MR. ROY: That is a long ton.

DR. ORTON: Yes sir, that is true. Now an acre of coal a foot thick would contain, on that basis, 1742 tons, or, taking it at 1,29, about 1754, something like that, and an average between these two will be 1750 tons. I have taken that then for one foot to the acre. A square mile, 640 acres, having coal a foot thick, will give us 640 times 1750 tons—1,120,000 tons. A seam three feet thick will give us 3,360,000 tons. A seam of four feet thick would give us 4,480,000 tons to the square mile. 5 feet, 5,600,000 tons, etc. Now we have the areas of the seams and we will estimate the thickness and the rest of the problem is a very simple matter. Let me give the areas county by county for the different seams, to which I will append my estimate of thickness.

Beginning in southern Ohio, in Lawrence county, we find that according to this basis of measurement, Lawrence county

has 269 miles of the Kittanning coals. Both are developed in parts of the county, but it often occurs that where one of these seams is found, the other is wanting. There is no such general concurrence of facts as to warrant the statement that is widely accepted, that if one is present the other is wanting. That is not by any means, universally true. But I have estimated that five feet will be thickness enough for the area, covering both seams. The Middle Kittanning seldom exceeds, and frequently falls below three feet. The Lower runs up to three and a half feet, as in the Newcastle field, but the seam is very uncertain, and I have concluded that five feet would make a large average.

Gallia county, though it does not show much coal in its outcrop, has a large area that is assigned on this basis to the Kittanning coal. We have 310 miles and I assume the same average of five feet for the two Kittanning coals there.

Jackson county has its wealth of coal in the lower seams, the Wellston and the shaft coals. It has but 41 miles of the Kittanning coals and they are very thin. The lower one is often wanting and the upper one runs less than three feet—28 inches in some mines I have seen. So I have given four feet for that 41 miles for Jackson county.

Vinton county has 115 square miles of the Kittanning coals with three feet assigned for thickness, because the middle seam runs very low and the lower is mainly absent.

Meigs county, which has no outcrop, but which we are obliged to count in, on the principle of measurement already explained, has 22 miles of the Kittanning coals, and we will give the same thickness as in Vinton, viz: three feet.

Athens county has 258 miles of Kittanning coals. I count 158 miles of six foot coal and 100 miles of four foot coal.

Hocking county has but 43 miles of the Kittanning seams, but the thickness is good, it is counted six feet.

Morgan county is another county in which the coal does not show on the surface, except to a small extent on the northern margin, but I think there is very little doubt that the coal is there under its great divides. Morgan county has 110 miles of coal, six feet in thickness.

Perry, 164 miles Kittanning coals, and I give Perry county seven feet thickness for the two. This is probably an exaggeration for the upper part of the county, but an addition may be necessary in the southern part.

Muskingum comes up grandly, with 350 square miles of the Kittanning coals and the two seams are quite steady. I give six feet to them.

Licking county has one mile of Kittanning coal, three feet thick.

In Guernsey county again, the coals are thinner and but one is generally present. I estimate three feet for 261 square miles.

Coshocton county has 199 square miles, three and a half feet in thickness.

Holmes county—I don't know what Captain Morris will think of this—Holmes county has but 30 miles, and I allow three feet for the thickness of the one seam.

Tuscarawas comes next with 317 square miles. The Middle Kittanning seam is largely mined but the coal runs very thin in the edge of Tuscarawas county and not a trace of the Lower coal is found to my knowledge in the entire county. So I assume three feet for the thickness here.

Harrison county we are obliged to suppose has 104 miles of Kittanning coals three feet thick.

Carroll county, 315 miles with three feet thickness.

Jefferson county, 100 miles with five feet thickness, because both seams now occur.

Columbiana comes up with a great margin. It holds a solid block at the north of these coals where the dip turns—where the dip changes to the south. It is the head of the great coal trough and we get a greater thickness from side to side than elsewhere. I estimate four feet as the thickness of the seams in this county.

In Mahoning county the drift covers the surface and I have not ventured to run the boundaries except on general principles. I have assigned 172 miles with three feet in thickness to the seams under discussion.

This makes 3873 square miles of Kittanning coals and the average thickness is four feet and a small fraction. I have

counted it up for that 3873 square miles. What is the total of this? The total is a figure that surprises me. 17,351,000,000 tons. I fear I am wearying you with this statistical work.

Coming to the Freeport coals, which lie inside the boundaries already traced and extend still further to the eastward, we get, in Lawrence county, 232 square miles. I estimate four feet for the Freeport coals. There is but one there. In Gallia county there are 360 square miles, and I estimate five feet for Gallia. Jackson has but six miles, but it is pretty good coal and I give four feet to that. Vinton has but 45 miles of the Freeport coals and I give four feet to it. Meigs has 190 square miles, with four feet thickness. Athens, 312 miles with four feet. Hocking, 12 miles with four feet. Perry, 61 miles with four feet. Muskingum, 296 miles with four feet. Noble, 6 square miles with six feet of thickness. Guernsey county, 353 miles, with six feet of thickness, owing to the great development of the Cambridge seam, the best portion of the state for that seam. Coshocton county has 8 miles, four feet in thickness. Belmont has 4 miles with four feet in thickness. Holmes 1 mile, four feet thick. Tuscarawas 97 miles, four feet thick. Harrison county, 206 miles, all under cover, or almost all, and four feet in thickness, but I feel sure of that work, I have very good data on some points there that show that the coal is where it is marked. Carroll has 271 miles, four feet thick. Stark, 10 miles, only found in the tops of the hills, four feet thick. Jefferson county has 224 miles, five feet in thickness. Columbiana county has 251 miles six feet thick. This gives us, 3149 square miles of Freeport coals in the state, with an assumed thickness of four and a half feet for the average. What is the grand total, 15,750,000,000 tons.

There remains then to be treated, the Pittsburgh coal in Jefferson, Harrison, Belmont and Monroe. In Monroe it is wholly under cover. I find 948 square miles and I give four feet to the average thickness. On the other side of the field we get Meigs and Gallia county, with 303 miles and four feet for the average thickness. That I think is a little too much for the Pittsburgh coal. That makes 1251 square miles for the Pitts-

burgh seam in Ohio, four feet in thickness, which gives a total of 5,600,000,000 tons of coal.

There remains then the Sewickley or Meigs Creek coal, with 620 square miles, four feet in thickness, which gives us an addition of 2,777,000,000 tons of coal.

Now what is the grand total? 8,893 square miles of area and what tonnage do we get? 41,478,000,000 tons. These figures of course are beyond all intelligible conception. Whenever we get into the millions, they stand for numbers that turn up in the process of calculation, but can give rise to no adequate conceptions in our minds. It takes a labored effort to reach any intelligent idea of what a million means.

There are certain large questions connected with these figures. How much is available for our use? Of course we cannot have it all to use. We never get all the coal out of a mine. Abatements are necessary. There are losses in mining. I might get various answers if I were to ask you how much coal is lost in mining. But I will say the loss ranges between 10 and 40 per cent. I hope none of you loses 40 per cent. The English miner leaves 40 per cent. in the deep coal in a great many instances. I will say 20 per cent. you will have to throw out probably, because as you go deeper under the hills and the hill has to be held up, you will be obliged to leave more coal.

I will add that there are "wants" in coal—and here I would like to appeal to those of you who know—"wants" in the coal due to erosion before the coal-making was finished, which we cannot lay down in our maps. The erosion you come upon in the dreadful sand troughs that sometimes traverse the coal in the Hocking Valley and Sunday Creek Valley especially will probably claim 10 per cent. of the total area. This is a hard subject to generalize upon.

Now then, gentlemen, these are figures that I give on my own responsibility. I do not believe them myself. I do not believe the coals extend as far as I put them and I would have to take off quite a percentage for that. I would take off 30 per cent. from what I have given here and I would have only 40 per cent. left. But that would give us 16,500,000,000 tons.

Now how long would that amount of coal last? That depends, of course, on the rate of use. Well, we have nearly reached 14,000,000 tons of Ohio coal per annum. In 1872, there were mined 5,315,000 tons. In 1873, 4,550,000 tons. In 1875, production began to advance and there were mined 4,864,000 tons. The next year it went down to 3,500,000, but in 1877 we get back again to 5,250,000. In 1879 it reached 6,000,000. In 1880, 7,000,000. In 1881, 8,225,000. In 1882, 9;450,000. Then there came three years in which there was a drop back. In 1883 we mined 8,229,000; in 1884, 7,640,000; in 1885, 7,816,000. Then up again in 1886 to 8,435,000. In 1887, 10,391,000; in 1888, 10,147,000; in 1889, 9,470,000; in 1890, 11,414,000 tons. You are the men that have made these figures. You are the men that have done this work. In 1891 the product was 12,864,000; in 1892, 13,562,000; and I suppose 1893 will not show as much as this. The curve will sag again at this point, but only for a short time.

Now here is a steady increase amounting to about 6 per-cent. in that long term of years. Six per-cent. on each previous year would give us figures, as I roughly calculate, about like this. Now it is not likely that the production of Ohio coal is going to stop just at this point. There is a great coal field on the east that is going out one of these days. The anthracite coal cannot last forever. By the middle or end of the next century, it is going to be done with. Then a greater strain will come upon the bituminous fields. Do you not think you are experiencing that already? Is not bituminous coal reaching a little further to the eastward than in previous years? Then we increase from 14,000,000 tons to 15,000,000, 16,000,000, 20,000,000, 25,000,000. Suppose we maintain the last figure for a long term of years. I do not forget the wonderful economy in the use of coal that is coming into operation through electricity. I do not forget we are learning to avail ourselves of some of these forces that the world has neglected so long. I do not forget that street cars are sweeping through Buffalo and that the cities of western New York are ablaze with light and that both light and power that come from the Falls of Niagara and that coal is to be made to do a great

deal more work in the future; that is, that a smaller amount of it will answer our demands in the years to come. But after all it looks as if we are bound to come before long to the condition which is already reached in England. Suppose we mined 25,000,000 tons a year, not twice what we are using now, how long would it stand us then. With a use of 25,000,000 tons a year, Ohio coal would last us quite a long term of years, several hundred years. And then what? But I will not speculate. I thank you for your patient attention. I will be thankful if you will take up these points for yourselves.

In conclusion I beg to disclaim all settled convictions upon the thickness of our coal seams and all settled convictions upon how far under drainage the boundaries may go. But we must have some boundary to work to and some thickness to assume, and I have taken those that I have given here as the best that I now see, and I invite your kindly criticism and consideration. (Applause.)

THE CHAIR: Ladies and gentlemen, I think none of us can fail to appreciate the honor Dr. Orton has done us in presenting us with this paper, embodying facts new and of the highest importance to us and to the world at large. The paper is open for discussion and there must be members of the institute here who would like to speak with regard to the matter, or at least in some way express their interest in the facts concerning which Dr. Orton has so interested and instructed us this evening. The paper is open for discussion.

CAPTAIN MORRIS: Mr. President, there is one thing about the Professor's paper that we can all say emphatically, that we have heard something to-night that we never heard before and we know something now we never knew before and I think it will be a very proper thing for each and every one of us who has any idea of the geological formation of the State of Ohio to think this matter over and to have our minds in such shape that we can, after deliberating over it, be so sure of it as the Professor is this evening. I am very much elated over that beautiful paper.

MR. LOVE: Mr. Chairman, I would move that the paper just read by Prof. Orton be published in the journal of the institute, allowing him to make such corrections as he deems necessary previous to its publication.

SECRETARY HASELTINE: That is always done.

MR. LOVE: My statement was made in answer to his suggestion.

THE CHAIR: I think the chair will assume that Dr. Orton's paper will be published in any way that he wishes to have it go into the hands of the printer. Are there any questions?

SECRETARY HASELTINE: Mr. Keigley asks if there is no coal in Washington.

DR. ORTON: There is no coal that we could have mapped, except a little of the Meigs Creek seam, but the truth is, our funds were exhausted before we got there and the work had to be left with this slight omission. I have made an explanation id the volume as to the ground of the omission. There are two maps you know that come in which are not shown. They are on a different scale. The Meigs Creek coal comes in at this point, and the Pittsburgh coal on that side. I have followed thick coal into Washington county on the south-western side—the Pomeroy coal.

SECRETARY HASELTINE: Now Doctor, if you are not too tired, you laughed a little at my maps at the World's Fair, but I stand by them all the same. You rather conveyed the impression that coal, as soon as it plunges under water level, is destined to stop. You have assumed 25 miles or something like that for the extension. Now what I wanted to ask was, on what theory you base your opinion, that it does not run continuously until it comes to the water level again at some other point.

DR. ORTON: Coal was formed in a marginal swamp, a swamp near the sea. These mile-stones we were talking about this afternoon bear witness that it was near the sea. Some of

these boulders that my friend Mr. Sharp has sent me were taken from the coal, boulders of sand-stone, well rounded. I have now a half dozen or more of these boulders, all of one character, and they show that there must have been means of transportation. It could not have been a river, because a river that would bring such a boulder would bring a great deal of mud besides. Perhaps it was a sheet of floating ice that brought it. You may listen with astonishment about ice in the carboniferous period, but there is a fair possibility that there has been an ice age or many of them before the last glacial period. But let thrt go. I think it is certain however that a coal swamp is a marginal swamp. I can think of a swamp growing around the shores of the gulf of Mexico to-day, but I cannot think of it as reaching out 50 miles into the gulf. There is one explanation that ought to be made there. A coal seam takes a long time for its growth. We ought to have more respect for it, because of its antiquity. A coal swamp is growing for a long term of years, and while it is growing, the sea margin may be either rising slowly or settling slowly. If rising it will give a chance for coal out in what was the sea at an earlier date. If settling, the coal may advance, and there will be a new margin formed. But I repeat, it is a question of fact. Give us all the facts you have or can get in regard to the extension of coal seams. The testimony of drillers, oil well and gas well drillers, it not very satisfactory, for they are not very particular on what they consider the minor points. They are not looking for coal, they are looking for oil sands. The facts they give us do not seem to them of great importance or to be deserving of special record.

MR. ROY: There could have been a good deal more said about our little deposit in Jackson county, and I might say a word or two about it. Years ago I made an estimate that there was 75,000,000 tons of that deposit. At Wellston it is not over two miles wide, and it does not run out on the outcrop, because it runs up into the air. After you pass a barren area, other outliers come in similar to the manner in which the coal lies in the Muskingum and Tuscarawas Valley. That is, there are great wants in it. In 20 years, that coal will be gone. They don't

want anybody to say that down there. We can't find it at all. Now it ought to extend down along the outcrop almost to the Ohio river, going through Scioto county, but we can't find a vestige of it.

DR. ORTON: It isn't there.

MR. ROY: Why isn't it there.

DR. ORTON: It did not stand on the right level to the sea. Either too deep or too high.

MR. ROY: I am glad you accept the fact that there are barren areas in the field. My idea is we have not one-tenth of the coal we thought we had, and that your estimate is too large. Take Coshocton county and Guernsey county, two or three miles below Cambridge, it is four or five foot coal. Up at the tunnel at Guernsey is only a few inches and there is more of that kind of coal than of good coal, so that I think, to count it good coal makes five or six times more coal than exists there.

DR. ORTON: Well, I think myself all these figures are pretty large.

MR. ROY: You know I have always held, but I will have to take it back, that the coal probably extended in a sheet, as the the worthy inspector said, to the river. I am inclined to think you are right and I am wrong.

SECRETARY HASELTINE: Mr. Chairman, I base my opinion largely upon my friend Mr. Roy's opinion. He read a very able paper here not long ago in which he identified all the coals in Jackson county with the Twelve Pole coal region and the Ohio river had accidentally slipped in and cut them off. (Laughter.)

MR. ROY: Mr. Chairman, if Mr. Haseltine had read that paper carefully, he would see that I only spoke of the coals that came up on the other side, comparing the field to a basin, as Prof. Orton has always told us, that the coals dipped towards the Ohio river, but I found them on the other side rising in the

opposite direction. The coals that went down under the water level disappeared. Prof. Orton insisted, and I am inclined to accept it now, that they went a few miles and were cut out. But on the other side, there was a growth of the coal vegetation and that the same seams that were growing on the Ohio side were growing at the same time ou the Virginia side of the margin, but that the great space between was water and that no coal was made there.

DR. ORTON: Yes sir, that is it.

MR. ROY: Then you do not think that the coals in West Virginia are the same as Ohio coals?

DR. ORTON: Not as continuous seams, to be followed in a straight line.

THE CHAIR: We have a paper from Prof. Sperr.